

## SURGERY

### The Ultimate Operation

(See Cover)

For weeks, and months, and even years, surgical teams at more than 20 medical centers around the world have been standing ready to make the first transplant of a heart from one human being to another. What they have been waiting for is the simultaneous arrival of two patients with compatible blood types—one doomed to die of some disease that has not involved his heart, and a second doomed to die of incurable, irreversible heart disease.

Last week, in two hospitals separated by almost 8,000 miles of Atlantic Ocean, the historic juxtaposition happened and the heart transplants were performed. The physicians who performed them thus reached the surgical equivalent of Mount Everest, followed automatically by the medical equivalent of the problem of how to get down—in other words, how to keep the patient and transplant alive.

In this, the team at Brooklyn's Maimonides Medical Center, headed by Dr. Adrian Kantrowitz, admitted "unequivocal failure." Their patient, a 19-day-old boy, died 6½ hours after he received a new heart. But the team of Dr. Christiaan Neethling Barnard, 44, which acted first at Cape Town, South Africa, had a more enduring success. Their patient, a 55-year-old man, was feeding himself and making small talk a week after his epochal surgery. At this time, as expected, there appeared the first signs of a tendency by his body to reject the transplant, but the doctors were confident that they could control this reaction.

"Go Ahead." The Cape Town drama began three months ago, when Louis Washkansky, a wholesale grocer, was admitted to suburban Groote Schuur Hospital with progressive heart failure. Because of two heart attacks, one seven years ago and the other two years ago, the burly patient's heart muscle was not getting enough blood through clogged and closed coronary arteries. He also had diabetes, for which he had been getting insulin. His liver was enlarged. Surgeon Barnard's cardiologist colleagues gave "Washy" (as he was known to World War II buddies in North Africa and Italy) only a few months to live. They shortened it to weeks as his body became edematous (swollen with retained water). Washkansky was dying, and knew it.

Denise Ann Darvall, 25, had no thought of death when

she set out with her father and mother to visit friends for Saturday-afternoon tea. In Cape Town's Observatory district, Edward Darvall stopped the car. His wife and daughter started across the street to a bakery to buy a cake when both were struck by a speeding car. Mrs. Darvall was killed instantly. Denise was barely alive, but only barely, on arrival at Groote Schuur Hospital. Her head and brain were almost completely destroyed. The emergency room called Dr. Barnard. The doctors agreed: Denise could not survive. Barnard took Darvall aside and explained what he wanted—the gift of a heart, unprecedented in history. Edward Darvall listened numbly as Barnard told him: "We have done our best, and there is nothing more that can be done to help your daughter. There is no hope for her. You can do us and humanity a great favor if you will let us transplant your daughter's heart." Said Darvall: "If there's no hope for her, then try to save this man's life." He signed the consent.

Dr. Barnard had already told Washkansky what he had in mind, adding: "You can have two days to think it over." Washkansky decided in two minutes: "Go ahead." Dr. Barnard now called in his team of 30 men and women, scattered for the summer weekend.

When did Denise Darvall die? Explains Dr. Marius Barnard, 40, younger brother of Christiaan and his right-hand assistant during surgery: "I know in some places they consider the patient dead when the electroencephalogram shows no more brain function. We are

on the conservative side, and consider a patient dead when the heart is no longer working, the lungs are no longer working, and there are no longer any complexes on the ECG."

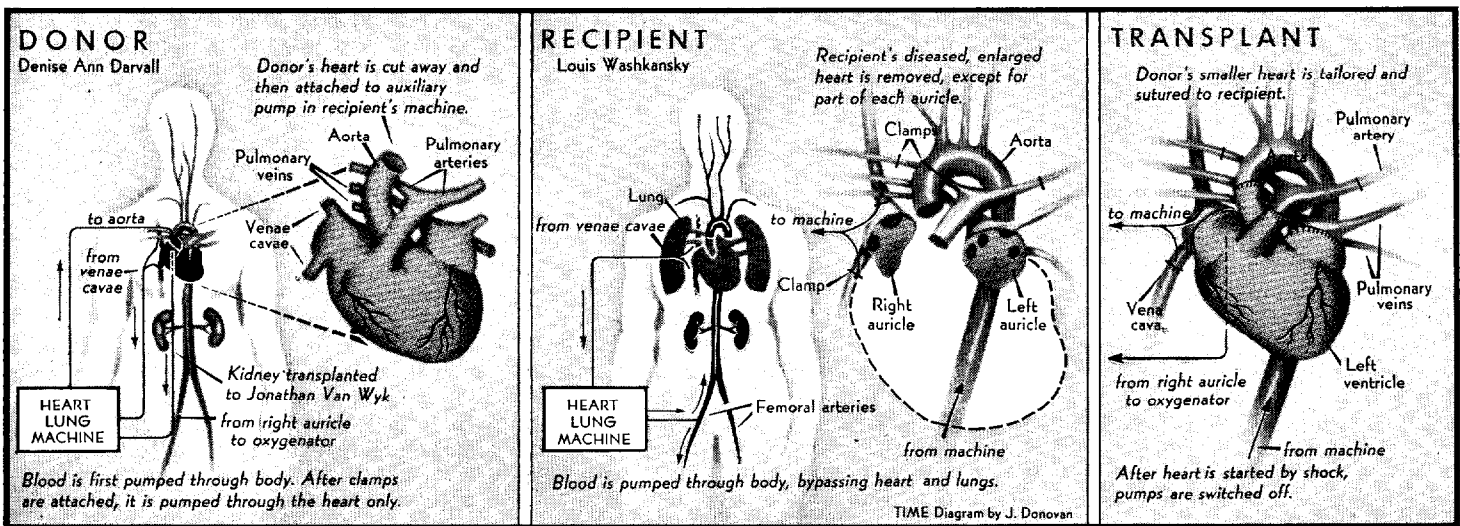
**Universal Donor.** Though Denise Darvall's heart had stopped beating and she was dead, her heart could not be allowed to degenerate. Irreparable cell damage begins at the temperature of a naturally cooling cadaver in 30 minutes. It can be postponed for two to three hours by cooling. The Barnard team took no chances. By this time, Denise's body was in an operating room a few feet from the operating room in which Washkansky lay. A surgeon opened her chest by a midline incision, snipped some ribs and exposed the heart with its attached blood vessels.

Near the arch of the aorta (*see diagram*) he inserted a plastic catheter tube, which was connected to a heart-lung machine. Another catheter, similarly connected, went into the right auricle. At this point, the whole body was perfused with oxygenated blood. The surgeons then clamped the aorta beyond the catheter and clamped the pulmonary artery and venae cavae, thus isolating the heart from the rest of the body, which thereafter received no circulation. With the heart-lung machine set at a low flow rate, the heart continued to have oxygenated blood pumped through it. And it was cooled to 73° F.

Meanwhile, Pathologist M. C. Botha was working in his laboratory with a sample of Denise's blood. Washkansky's type was A-positive; Denise's was O-negative. She was the ideal "universal donor." There was no time for Dr. Botha to try matching their white blood cells so that the surgeons could estimate how strong a rejection reaction Washkansky's system would mount against the foreign protein of Denise's heart.

Simultaneously, Washkansky was anesthetized, and at 2:15 a.m. Sunday one of the surgeons opened his chest. Assisting Christiaan Barnard, in addition to his brother Marius, were Drs. Rodney Hewitson and Terry O'Donovan. The main blood vessels were clamped in much the same way as Denise's had been, but in this case the heart-lung machine was to serve a directly opposite purpose: to circulate oxygenated blood through all of Washkansky's body except his about-to-be-discarded heart.

"A Cup of Tea." Exercising the captain's prerogative, Dr. Christiaan Barnard moved into the first operating room and cut eight blood vessels to free Denise Darvall's heart; then he severed it from its ligament moorings. It was disconnected from the pump, and was carried to Washkansky's room, where it was connected to a



small-capacity heart-lung machine. There it lay, chilled and perfused with oxygenated blood, while Surgeon Barnard removed most—but not quite all—of Washkansky's heart. He left in place part of the outer walls of both the auricles, the right carrying the two entrance holes of the venae cavae, the left carrying the four entrance holes of the pulmonary veins. The rest of the heart, flabby and scarred, he set aside.

In painstaking sequence, Dr. Barnard stitched the donor heart in place. First the left auricle, then the right. He joined the stub of Denise's aorta to Washkansky's, her pulmonary artery to his. Finally, the veins. Assistant surgeons removed the catheters from the implant as Barnard worked.

Now, almost four hours after the first incision, history's first transplanted human heart was in place. But it had not been beating since Denise died. Would it work? Barnard stepped back and ordered electrodes placed on each side of the heart and the current (25 watt-seconds) applied. The heart leaped at the shock and began a swift beat. Dr. Barnard's heart leaped too. Through his mask, he exclaimed unprofessionally but pardonably, "Christ, it's going to work!" Work it did.

The heart-lung pump was still running. Now it was reset to warm the blood. After ten minutes it was switched off to see whether the transplanted heart could carry the whole burden of Washkansky's circulation. It was not yet quite ready, and on went the pump again for another five minutes. This time, when it was stopped, the heart did not falter. It could do the work. The surgeons closed Washkansky's chest. The operation, "from skin to skin," had taken 4½ hours. It was 7 a.m. "I need a cup of tea," said Dr. Barnard.

**Space to Spare.** An hour later, Washkansky regained consciousness and tried to talk. So carefully isolated from possible infection that even his wife Ann was persuaded not to visit him for four days, he showed improvement day by day. After 36 hours he complained of hunger and ate a typical hospital meal, including a soft-boiled egg. As a fur-

ther guard against infection, the doctors dosed him with antibiotics. His donated heart, healthy and compact, jumped around somewhat uneasily in the cavity left by his own enlarged heart, but this space would soon shrink naturally. The heart gradually slowed its beat to 100 per minute. (Surgeon Barnard's had been a frenetic 140 when he finished the operation.)

Among the several courses open to them to try to blunt the rejection mechanism, Washkansky's doctors chose to use two drugs, azathioprine (Imuran) and cortisone, plus radiation. At first, to avoid moving their patient, they administered gamma rays with an emergency cobalt-60 unit, somewhat resembling a dentist's X-ray machine, rigged up in his room. After four days, when Washy was waving at photographers and joshing with doctors and nurses, he was considered strong enough to stand a quarter-mile trundle to the regular radiation treatment center. At week's end, when his white-blood-cell count rose, the doctors still had more drugs

in reserve to beat back the rejection mechanism, and they stepped up his cobalt-60 treatments. Washkansky's liver shrank to nearer normal size; Denise's heart and his kidneys worked so well together that he lost 20 lbs. of edema fluid.

**Double Chill.** While South Africa was proudly rejoicing, the U.S. transplant team was just beginning. In wintry Brooklyn, Dr. Kantrowitz had put his team on full alert at about the same time as Dr. Barnard was alerting his. His 19-day-old patient, the intended heart-transplant recipient, had been born blue. The child was a victim of severe tricuspid atresia—constriction, to the point of almost total closure, of the three-leafed valve that normally regulates the flow of blood from the right auricle to the right ventricle on its way to the lungs for oxygenation. There is no way to correct this condition surgically, and its victims live no more than a few weeks. Justification for a transplant was clear.

The problem was to find a donor. Maimonides sent telegrams to 500 hospitals across the U.S., asking to be notified of the birth of an anencephalic baby (with a malformed head and virtually no brain) or one with such severe brain injury that it could not long survive. There are a thousand or more such cases every year in the U.S., but long days passed before Dr. Kantrowitz got the word that he was awaiting. It came from Philadelphia's Jefferson Hospital: an anencephalic boy was born there the day after Washkansky's surgery. Dr. Kantrowitz talked with the parents, whom he described, in broad understatement, as "intelligent and understanding." They agreed to let Kantrowitz take their baby to Brooklyn to die, and to transplant his heart.

He died at 4:20 a.m. Wednesday, across the room from the recipient baby, who was being kept alive in a respirator that supplied him almost 100% oxygen. Since heart-lung machines are impractical for such small infants, the 22-man transplant team chilled the dead baby's body to retard damage to the heart. The doctors had already begun

cooling the recipient baby in a water bath to 59°F. After 40 minutes, they were ready to cut. One group excised the dead baby's heart while another excised the recipient's. In a mere 30 minutes Dr. Kantrowitz was able to join the aorta, the great veins and pulmonary arteries. From skin to skin, the operation took 2½ hours.

The recipient baby, whose identity was kept secret, was a healthy pink as his donated heart pumped normally oxygenated blood. Other criteria for the patient's recovery all seemed favorable. But after 6½ hours, the heart suddenly stopped. There had been no time for the rejection mechanism to intrude—that takes days or weeks, and is, besides, less likely to be severe in infants. Dr. Kantrowitz, drawn and shaken, con-

ing normally at week's end. Washkansky was making wisecracks: "I'm a Frankenstein now. I've got somebody else's heart." (And making the common error of confusing the fictional Dr. Frankenstein with the monster he made.) Washkansky was well enough to go through a radio interview with a doctor. He ate well, and said his only complaint was that he was aching from being kept too long lying in bed.

Dr. Barnard was talking of sending Washkansky home in a couple of weeks. In this he could have been overoptimistic. The possibility remained that he might be as cruelly disappointed as Dr. Kantrowitz by the sudden failure of the transplant. At best, there could be endless complications. Yet the mere performance of the operation set a mile-

Not until the present century did it become clear that safe blood transfusions depended on matching at least the A, B and O groups of red cells. The Rh factor came still later. In the early 1900s, U.S. Physiologist Charles Claude Guthrie and French Biologist-Surgeon Alexis Carrel appeared for a while to have broken down the barriers against transplants. They devised most of the basic surgical techniques, notably how to stitch slippery little blood vessels together so that the joints would neither leak nor close down with clots. Guthrie grafted a second head onto a dog half a century before the Russians did it in 1959. Carrel kept part of a chicken's heart "alive" in a laboratory flask. But they still could not get organ grafts between two animals to take for any length of time.

The full explanation of one man's rejection of another's flesh had to wait until 1953, when Britain's Sir Peter Brian Medawar revealed details of the immune mechanism involving the white blood cells. These are the body's main line of defense against viruses, which have protein coatings, and against many other germs. They react just as strongly against any "foreign" (meaning another person's) protein. They make antibody to destroy such invaders.

**Spare Kidneys.** This explained why the first few kidney transplants, begun at Boston's Peter Bent Brigham Hospital in the early 1950s, had failed. It also explained the success of Dr. Joseph E. Murray's first transplant of a kidney between identical twins, done at the Brigham in 1954. Since only one patient in 300 or more has an identical twin available—let alone willing—to donate a kidney, researchers in a dozen branches of medical science have been trying ever since to devise a way of switching off the immune or rejection mechanism long enough to let a transplant "take," then restore it so that the recipient will not be a helpless prey to every passing infection.

Research doctors have had some, but by no means complete, success with X rays, and with two classes of drugs—the anti-cancer chemicals and cortisone-type hormones. They have devised increasingly complex methods of matching white blood cells to reduce antibody formation, and of making anti-lymphocyte serum in horses to reduce the white cells' activity. This partial success has been sufficient to give today's recipient of a kidney transplant (from close kin or even an unrelated cadaver) at least a 65% chance of surviving.

Every normal person has two kidneys, and since he can live on one, that means he has one to spare. The corpses of healthy people killed in accidents provide two. So although the demand still far exceeds the supply, the kidney transplant's problem is minor compared with that of the surgeon who would transplant a liver. Each man has only one, and cannot live without it. The world's pioneer in transplanting livers, Dr. Thomas Starzl of the University of

ceded that he and his colleagues had no idea why they had failed in their attempt "to make one whole individual out of two individuals who did not have a chance of survival." The autopsy indicated no surgical error; microscopic findings, which may disclose the actual cause of death, will take weeks.

**No Regrets.** The donor baby's understanding parents were soon identified as Attorney Keith Bashaw, 40, and his wife Celeste, 31, who live in Cherry Hill, N.J., across the Delaware from Philadelphia. They have two healthy children, aged 7 and 5. The anencephalic third was delivered by caesarean section. Said Bashaw: "We thought we could turn our sorrow into somebody else's hope. We're sorry it didn't work—but we're not sorry we did it."

Edward Darvall had still less reason to regret his decision. Not only was Denise's heart working in Washkansky's chest, but her right kidney was transplanted to a Colored\* boy, ten-year-old Jonathan Van Wyk, and was function-

stone along the endless road of man's struggle against disability.

**Slippery Stitching.** Surgeons have dreamed for centuries of making just the sort of replacement of a diseased or injured limb or organ that Dr. Barnard made last week. But when they tried to make their dreams reality, they found themselves engaged by invisible but seemingly invincible forces, mysterious beyond their understanding. Italian surgeons during the Renaissance occasionally succeeded in repairing a sword-slashed nose or ear with flesh from the patient's own arm, but got nowhere with person-to-person grafts. The first widely attempted transplants were blood transfusions, from lamb to man or man to man. Almost all failed—in many cases, fatally—and no one knew why a few succeeded. Skin grafts, often attempted after burns, slough off after a few weeks unless they are taken from another part of the patient's own body. The first consistently successful human homografts (between two individuals of the same species), beginning in 1905, involved the cornea—the transparent, plastic covering of the eyeball which has no blood circulation.

\* The South African designation for one of mixed racial origin.

Colorado, has obtained 15 so far, with encouraging results in four recent operations on little girls (TIME, Dec. 1). Comparable problems of supply confront the University of Minnesota's Dr. Richard C. Lillehei, who has transplanted the pancreas with duodenum attached, and an almost complete intestinal tract.

**Just a Pump.** For the surgeon who would transplant a heart, the problems are manifold and more difficult, with moral and ethical as well as medical considerations involved. Since ancient times, the heart has been apostrophized as the throne of the soul, the seat of man's noblest qualities and emotions—as it still is in poetry and love songs. But even the Vatican newspaper *L'Osservatore Romano* noted last week that "the heart is a physiological organ and its function is purely mechanical." In fact, the heart is nothing more than a pump. There is no more soul or personality in a heart than in a slice of calf's liver.

But on one score the ancients were right. The heart is essential to life in a more immediate, temporal sense than any other organ, even the brain. The human body can survive for years in a coma, with no conscious brain function—but only for minutes without a beating heart. So the presence of a heart-beat, along with breathing, has long been the basic criterion for distinguishing life from death. It still is, in the vast majority of cases, despite some special situations in which the brain's electrical activity is a more reliable index. (So far, no surgeon has seriously considered transplanting a brain, because, beyond the forbidding technical difficulties, this would be akin to transplanting a person. Similarly, transplantation of entire gonads—ovaries or testicles—might carry with it a change in hereditary material.)

The real moral and ethical difficulty in heart transplants arises from medical uncertainty. Even when the heart has "stopped cold" and there is no more respiration, the condition is often reversible—as is proved countless times every day by first-aid squads and life-guards as well as doctors. The surgeon wants the donor's heart as fresh as possible, before lack of oxygen causes deterioration or damage—that is, within minutes of death. This has raised the specter of surgeons' becoming not only corpse snatchers but, even worse, of encouraging people to become corpses. The question remains: Where should the line be drawn between those to be resuscitated and those not to be?

Equally acute is the ethical problem regarding the proposed recipient of the heart. Obviously he is close to death, or such drastic surgery would not be contemplated. Yet his own heart must be cut out, which is tantamount to killing him, while he still retains vitality enough to withstand the most Draconian of operations. If the transplant should fail, he will certainly die. Thus the surgeons will, in effect, have killed him (as they might in any major opera-

tion), no matter how lofty their motive in trying to prolong his life and make it more satisfying.

**Once from an Ape.** So far, surgeons have thought of three possible replacements for an incurably failing heart: an animal's heart, another human heart, and a completely artificial heart. The animal heart has been used only once, in a case that illuminated both sides of the surgeon's dilemma. At the University of Mississippi Medical Center, Dr. James D. Hardy had, on three occasions, a patient dying of brain injuries who would have been a suitable donor—but he had no recipient. Twice, when he had potential recipients of a transplant, he had no

tem" to trigger its beats. This system speeds up in response to outside nervous stimulation (excitement) to meet the body's resulting greater demands for blood and oxygen. But even with no external nerve connections, it responds to excitement in essentially the same fashion through the action of adrenal hormones.

Dr. Shumway also introduced a refinement of technique in heart transplants used by both Dr. Barnard and Dr. Kantrowitz last week. In animal surgery, it had been customary to remove the entire heart. This meant severing and later rejoining not only the two great arteries, but also two great veins returning spent blood to the heart and

human donors. One candidate to receive a transplant, who seemed to be dying after a heart attack, bewildered the surgeons by getting well enough to go home. When the other was undeniably dying from progressive failure of his heart, Dr. Hardy gave him a chimpanzee's heart. The ape's heart was too small for the big man, and it failed within two hours. No other animals' hearts have been seriously considered for transplantation into man, despite the poetic appeal of a lion's heart. And even apes' hearts are too scarce to supply the predictable demand.

**Fail-Safe Protection.** Since animals seem of little help, surgeons have been forced back on human sources. Here, Stanford University's Dr. Norman E. Shumway could offer reassurance from many years of experimental surgery on dogs. A nagging question had been: What about the heart's nerve connections, since these cannot be reestablished in transplant surgery? Dr. Shumway's answer: It doesn't matter. Like practically everything else in nature, the heart has fail-safe protection. It has an internal, independent, electrical "ignition sys-

tem" to trigger its beats. This system speeds up in response to outside nervous stimulation (excitement) to meet the body's resulting greater demands for blood and oxygen. But even with no external nerve connections, it responds to excitement in essentially the same fashion through the action of adrenal hormones.

**Other People's Cigarettes.** Shumway and Lillehei, like many of today's foremost surgeons and professors of surgery, absorbed much of what they know of the technique and exploratory spirit of their calling from the University of Minnesota's great (and lately retired, at 68) Dr. Owen H. Wangensteen. So did Christiaan Barnard, who was at Minnesota in 1953-1955. Barnard, the son of a Dutch Reformed minister, had always wanted to be a doctor. His father, on a cash income of \$56 a month, gave three of his four sons a university education.

Wangensteen, noted as a driver of men, did not have to drive Barnard. He remembers that Barnard once operated on 49 dogs unsuccessfully in an attempt to learn about an intestinal abnormality in the newborn. "On the 50th

time he succeeded; that was typical of his singleness of purpose," Wangenstein says. Outside the operating room, then as now, Barnard was tense, and paced with restless energy smoking other people's cigarettes. Inside the operating room Barnard kept himself tightly controlled, talked little, learned much. As a resident in surgery, he crowded into three years the work and experience for which most men take four or five, gaining himself Master of Science and Ph.D. degrees in surgery to add to his Cape Town medical degree.

Back home, Dr. Barnard continued transplant research while practicing heart surgery and running a family. (With two children, he was best known in South Africa, until last week, as the father of a champion water skier, Deirdre, 17.) When he read of the dog onto which the Russians had transplanted a second head, he declared "There's nothing to it." He did two such operations himself, made movies of the dog operations—and took the movies with him as evidence when he went to Moscow to see whether he could learn anything from the Russians. In fact, he has learned more from former colleagues in the U.S. and from keeping up with their research.

Last week, after his brilliant operation, his surgical colleagues were full of praise. Said famed Heart Surgeon C. Walton Lillehei (Richard's eldest brother), newly named surgeon-in-chief at New York Hospital: "Barnard's achievement was a fantastic piece of surgery, no matter what happens later." Houston's Dr. Michael E. DeBakey (*TIME* cover, May 28, 1965) was just as enthusiastic: "This breaks the ice—it's a real breakthrough—a great achievement." South Africans, from Prime Minister Balthazar J. Vorster down, were understandably elated that a native son had brought such showers of applause upon their young republic.

**Ventricle Work.** Despite the milestone quality of Barnard's accomplishment, his transplant was only the beginning of the road, not the end. There will continue to be, in the foreseeable future, many more potential heart recipients than donors, and the social problems—such as deciding who shall get a transplant—are even more forbiddingly complex than the surgical. The ultimate solution, DeBakey insists, is a completely artificial heart. He has been working on such devices for years. Walton Lillehei has a valveless, oxygen-powered device now ready for use as an external "heart assist," which he hopes can eventually be modified for implantation to do the work of both heart and lungs. DeBakey asserts, characteristically, that if the U.S. would spend as generously for this research as it does to launch satellites—"say four or five billion dollars"—the artificial heart could be perfected much sooner.

The National Institutes of Health also decided in 1963 that the eventual remedy for incurable heart disease must lie

in a complete artificial heart, and set 1972 as the tentative target date for getting one to work. Last year N.I.H. concluded that this was unrealistic at this time, and dumped much of the \$8,700,000 available into research grants for the perfection of "half-hearts"—devices to assist the left ventricle, or take over its work entirely for a time.

Both DeBakey and Kantrowitz have obtained good results with half-hearts in one or two cases. DeBakey's best patient, Mrs. Esperanza del Valle Vásquez, was on heart assist for ten days after the implantation of two artificial valves in her heart. Now she puts in an eight-hour day on her feet, running her Mexico City beauty parlor. On hearing about Washkansky last week, she bumbled:

"How marvelous! I want to write to this man—I have so much to tell him." But Shumway insists that in 1,500 operations in which he has opened hearts to correct defects, he has seen not one patient who needed a heart-assist device. The N.I.H. project, he believes, is justifiable only as a step toward the complete artificial heart.

Since that achievement is years away, human-heart transplants will be a valuable intermediate stage. More will now be attempted and with far less misgiving. However stormy Louis Washkansky's near-future course might be, and whatever the ultimate fate of the transplant, the worldwide acclaim for Dr. Barnard's daring and his immediate success have initiated changes in both professional and public attitudes. Surgeons who did not want to take the risks attendant upon being first will now attempt transplants. More medically suitable recipients will be willing to accept a transplant with its inevitable hazards. And more people will be willing to sanction the gift of a heart to help an ailing fellow man.